WHAT IS CLAIMED IS:

Claims 1-7
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1. A method for determining a magnetic force profile of a sample by using a cantilevered probe having a magnetic tip, the method comprising the steps of:

traversing the tip along a predetermined path on the surface of the sample, the tip being proximate the surface of the sample while traversing along the predetermined path;

determining the sample surface topography along the path;

substantially canceling the sample surface potential along the path using the determined sample surface topography; and

determining magnetic force data along the path based on the determined surface topography, wherein the determined magnetic force data is not magnetic force gradient data and the determined magnetic force data includes substantially no components from the sample surface potential.

2. The method as recited in claim 1, wherein the steps of substantially canceling the sample surface potential and determining magnetic force data are performed substantially simultaneously.

3. The method as recited in claim 1, wherein the steps of determining the sample surface topography, substantially canceling the sample surface potential, and determining magnetic force data are performed substantially simultaneously.

4. The method as recited in claim 1, wherein the step of substantially canceling the sample surface potential comprises:

determining the sample surface potential along the path based on the determined sample topography;

applying a dc signal to the tip, the dc signal substantially canceling the sample surface potential.

5. The method as recited in claim 4, wherein the step of determining sample surface potential is performed with scanning surface potential microscopy.

6. The method as recited in claim 4, wherein the step of determining sample surface potential comprises applying an ac signal to the tip, wherein the ac signal is set to a resonant frequency of the cantilevered tip.

7. The method as recited in claim 6, wherein the step of determining magnetic force data comprises applying an ac signal to the sample, the frequency of the ac signal applied to the sample being different from the frequency of the ac signal applied to the tip.

8. A method for determining impedance information of an interface in a sample, the method comprising the steps of:

(a) applying an ac voltage to the sample, laterally across the interface, the ac voltage having a predetermined frequency;

(b) disposing a cantilevered tip in a first position proximate to a surface of the sample;

(c) measuring a first response of the cantilevered tip with the cantilevered tip in the first position;

(d) placing the cantilevered tip in a second position proximate to the surface of the sample, the interface being between the first position and the second position;

(e) measuring a second response of the cantilevered tip with the cantilevered tip in the second position; and

(f) determining impedance information of the interface based upon the measured first response and the measured second response.

9. The method as recited in claim 8, wherein the step of:

measuring a first response comprises measuring a first phase angle of deflection of the cantilevered tip;

measuring a second response comprises measuring a second phase angle of deflection of the cantilevered tip; and

determining impedance information comprises:

determining a phase shift based upon the first phase angle and the second phase angle; and

determining impedance information of the interface based upon the phase shift and the frequency of the ac voltage.

10. The method as recited in claim 9, wherein the step of determining impedance information further comprises determining an impedance product of the interface according to:

$$\tan(\varphi_{gb}) = \frac{\omega C_{gb} R_{gb}^2}{(R + R_{gb}) + R\omega^2 C_{gb}^2 R_{gb}^2}$$

where C_{gb} is the capacitance of the interface;

R_{gb} is the resistance of the interface;

ω is the frequency of the ac voltage;

φ_{gb} is the phase shift; and

R is a resistance of a current limiting resistor in series with the sample.

11. The method as recited in claim 9, further comprising the step of:

selecting the frequency ω of the ac voltage such that $\tan(\varphi_{gb})$ is proportional to ω^{-1}; and

wherein the step of determining impedance information further comprises determining the capacitance of the interface according to:

$$\tan(\varphi_{gb}) = \frac{1}{\omega R C_{gb}}$$

where C_{gb} is the capacitance of the interface;

ω is the frequency of the ac voltage;

φ_{gb} is the phase shift; and

R is a resistance of a current limiting resistor in series with the sample.

12. The method as recited in claim 9, further comprising the step of:

selecting the frequency ω of the ac voltage such that $\tan(\varphi_{gb})$ proportional to ω; and

wherein the step of determining impedance information further comprises determining the resistance of the interface according to:

$$\tan(\varphi_{gb}) = \frac{\omega C_{gb} R_{gb}^2}{(R + R_{gb})}$$

where R_{gb} is the resistance of the interface;

C_{gb} is the capacitance of the interface;

ω is the frequency of the ac voltage;

φ_{gb} is the phase shift; and

R is a resistance of a current limiting resistor in series with the sample.

13. The method as recited in claim 8, wherein the step of:

measuring a first response comprises measuring a first amplitude of deflection of the cantilevered tip;

measuring a second response comprises measuring a second amplitude of deflection of the cantilevered tip; and

determining impedance information comprises:

determining an amplitude ratio based upon the measured first amplitude and the measured second amplitude; and

determining an impedance of the interface based upon the amplitude ratio and the frequency of the ac voltage.

14. The method of claim 13, wherein the step of determining the impedance further comprises determining the impedance according to:

$$\beta^{-2} = \frac{\left\{(R + R_{gb}) + R\omega^2 C_{gb}^2 R_{gb}^2\right\}^2 + \omega^2 C_{gb}^2 R_{gb}^4}{R^2\left(1 + \omega^2 C_{gb}^2 R_{gb}^2\right)^2}$$

where β is amplitude ratio across the interface,

C_{gb} is the capacitance of the interface,

R_{gb} is the resistance of the interface,

ω is the frequency of the ac voltage, and

R is a resistance of a current limiting resistor in series with the sample.

15. The method as recited in claim 8, wherein the step of:

measuring a first response comprises the steps of:

measuring a first phase angle of deflection of the cantilevered tip; and

measuring a first amplitude of deflection of the cantilevered tip;

measuring a second response comprises:

measuring a second phase angle of deflection of the cantilevered tip; and

measuring a second amplitude of deflection of the cantilevered tip; and

determining impedance information comprises:

determining a phase shift based upon the measured first phase angle and the measured second phase angle;

determining an amplitude ratio based upon the measured first amplitude and the measured second amplitude; and

determining an impedance of the interface based upon the phase shift and the amplitude ratio.

16. The method as recited in claim 15, wherein the step of determining an impedance of the interface comprises solving the following equations:

$$\beta^{-2} = \frac{\left\{\left(R + R_{gb}\right) + R\omega^2 C_{gb}^2 R_{gb}^2\right\}^2 + \omega^2 C_{gb}^2 R_{gb}^4}{R^2\left(1 + \omega^2 C_{gb}^2 R_{gb}^2\right)^2}$$

$$\tan\left(\varphi_{gb}\right)=\frac{\omega C_{gb}R_{gb}^{2}}{\left(R+R_{gb}\right)+R\omega^{2}C_{gb}^{2}R_{gb}^{2}}$$

where β is amplitude ratio across the interface,

C_{gb} is the capacitance of the interface,

R_{gb} is the resistance of the interface,

φ_{gb} is the phase shift;

ω is the frequency of the ac voltage, and

R is a resistance of a current limiting resistor in series with the sample.

17. The method as recited in claim 15, further comprising the steps of:

repeating each step of claim 15, for each of a predefined plurality of ac voltage frequencies; and

determining an impedance of the interface as a function of frequency based upon the determined phase shifts and amplitude ratios.

18. The method as recited in claim 15 wherein the step of determining an impedance further comprises determining the impedance of the interface based upon the phase shift and amplitude ratio and the frequency of the ac voltage by using the circuit termination comprised of average resistive and capacitive components determined by conventional impedance spectroscopy by measuring the frequency dependence of phase angle or measuring phase angle and amplitude ratio at a single frequency with a least square fit procedure.

19. The method as recited claim 15 further comprising the steps of:

repeating each step of claim 15 and applying a first dc signal laterally across the interface while performing each measuring step;

repeating each step of claim 15 and applying a second dc signal laterally across the interface while performing each measuring step; and

determining dc signal bias dependence of the interface resistance and capacitance based upon the first and second dc signal.

20. A system for determining impedance information of an interface in a sample, the system comprising:

a function generator that applies an ac voltage having a defined frequency and a dc voltage to the sample;

a cantilevered tip for placement proximate to the sample;

a controller, coupled to the cantilevered tip, that measures a deflection of the cantilevered tip;

a lock-in amplifier, coupled to the function generator and the controller, that determines the phase shift and amplitude of the deflection of the cantilevered tip; and

a processor that determines an impedance based value of the interface based on the phase shift and the frequency of the ac voltage.